

Eutrophication (Nutrient Pollution)

Natural eutrophication is the process by which lakes gradually age and become more productive. It normally takes thousands of years to progress. However, humans, through their various cultural activities, have greatly accelerated this process in thousands of lakes around the globe. Cultural or anthropogenic "**eutrophication**" is water pollution caused by excessive plant nutrients. During the 1960's, Lake Erie was undergoing rapid cultural eutrophication and was the subject of much concern. The ELA was established in 1968 to experimentally investigate this problem. Between June, 1969 and May, 1976, it was virtually the sole focus of whole-ecosystem experimental studies at the ELA.

Humans add excessive amounts of plant nutrients (primarily phosphorus, nitrogen, and carbon) to streams and lakes in various ways. Runoff from agricultural fields, field lots, urban lawns, and golf courses is one source of these nutrients. Untreated, or partially-treated, domestic sewage is another major source. Sewage was a particular source of phosphorus to lakes when detergents contained large amounts of phosphates. The phosphates acted as water softeners to improve the cleaning action, but they also proved to be powerful stimulants to algal growth when they were washed or flushed into lakes.

The excessive growth, or "blooms", of algae promoted by these phosphates changed water quality in Lake Erie and many other lakes. These algal blooms led to oxygen depletion and resultant fish kills. Many native fish species disappeared, to be replaced by species more resistant to the new conditions. Beaches and shorelines were fouled by masses of rotting, stinking algae. A means to control this problem became a paramount need.

Using small, natural lakes as experimental systems, scientists at the ELA were able to add various combinations of nutrients and determine which of the major plant nutrients (carbon, nitrogen, phosphorus) was the key to controlling cultural eutrophication in lakes. Over a number of years, seven different ELA lakes (227, 304, 302, 261, 226, 303, 230) were experimentally fertilized in various ways. Two of these lakes (227 and 226) were particularly important in demonstrating that phosphorus was the key nutrient for the control of eutrophication.



Aerial view of Lake 227 circa 1975, showing the many marker floats used for intensively studying this small, experimentally fertilized lake.

Studies of gas exchange and internal mixing in **ELA lake 227** during the early 1970's clearly demonstrated that algae in lakes were able to obtain sufficient carbon dioxide, via diffusion from the atmosphere to the lake water, to support eutrophic blooms. Other studies in the same lake demonstrated that certain blue green "algae" (Cyanophytes or Cyanobacteria) were able to "fix" nitrogen that had diffused naturally into the lake from the air, thereby making the nitrogen available for supporting algal growth.

ELA Lake 226 was the site of a visually spectacular experiment. The lake was divided into two approximately equal portions using a plastic divider curtain. Carbon and nitrogen were added to one half of the lake, while carbon, nitrogen **and phosphorus** were added to the other half. For eight consecutive years, the side receiving phosphorus developed eutrophic algal blooms, while the side receiving only carbon and nitrogen did not (see photo, below). However, after only two years, this experiment convinced even the skeptics that phosphorus is the key nutrient. A multi-billion dollar phosphate control program was soon instituted within the St. Lawrence Great Lakes Basin. Legislation to control phosphates in sewage, and to remove phosphates from laundry detergents, was part of this program.



View from above Lake 226 divider curtain in August 1973. The bright green colour results from bluegreen algae (Cyanobacteria), which are growing on phosphorus added to the near side of the curtain.

By the mid-1970's, North American interest in eutrophication had waned. However, this "nutrient pollution" problem remains the number one water quality problem worldwide. Eutrophication research at the ELA has continued in Lake 227, albeit on a much reduced scale. After more than three decades, ELA scientists continue to unravel the details of algal responses to nutrients and the food chain effects that accompany them.



Aerial view of Lake 227 in 1994. Note the bright green colour caused by algae stimulated by the experimental addition of phosphorus for the 26th consecutive year. Lake 305 in the background is unfertilized.
(photo by Karen Scott)